



RADIOPHYTOREMEDIATION AND SUSTAINABLE MANAGEMENT OF RADIONUCLIDE POLLUTED AREAS

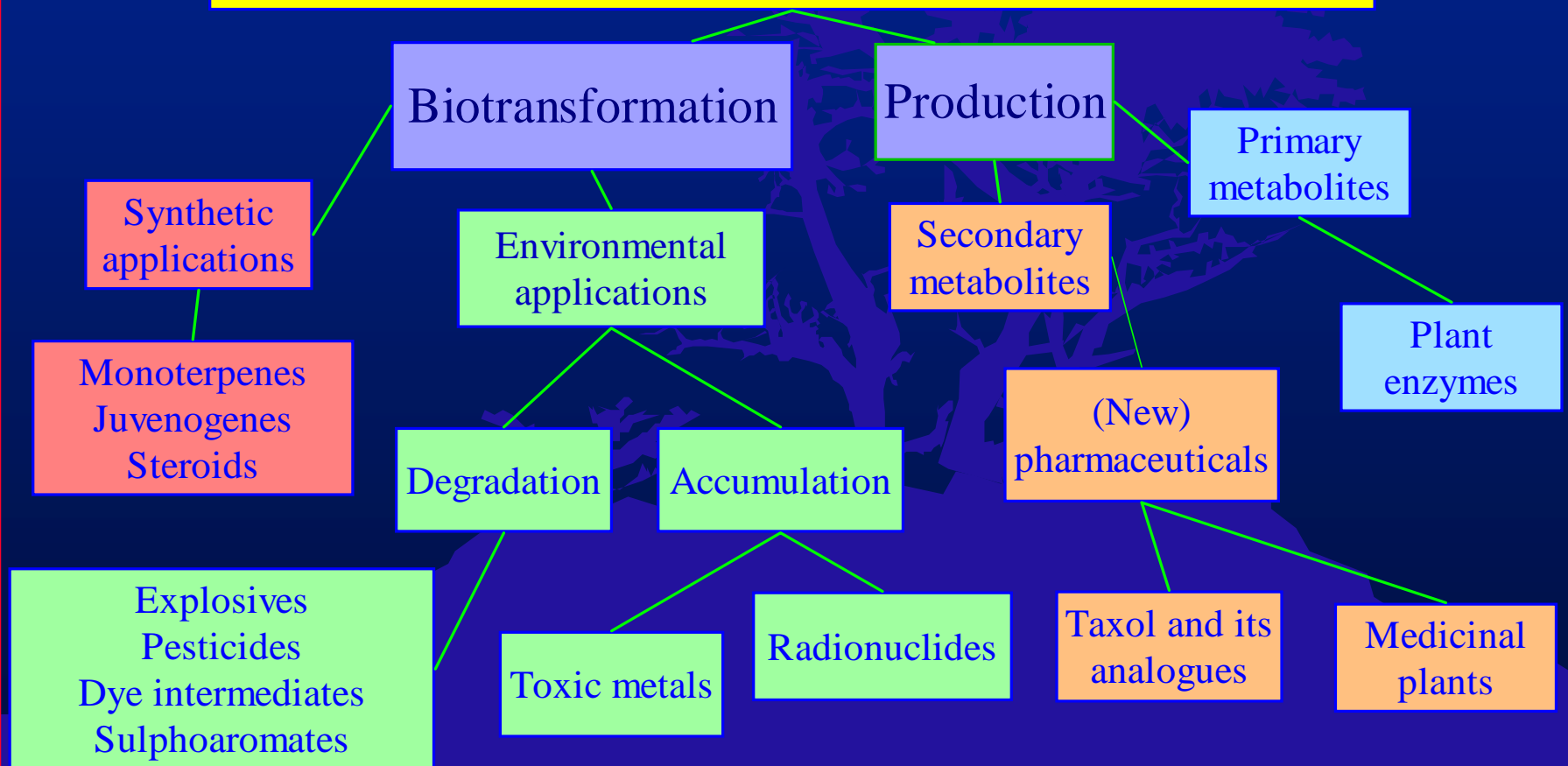
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Production and biotransformation of biologically active compounds by plant tissue cultures



URANIUM MILL



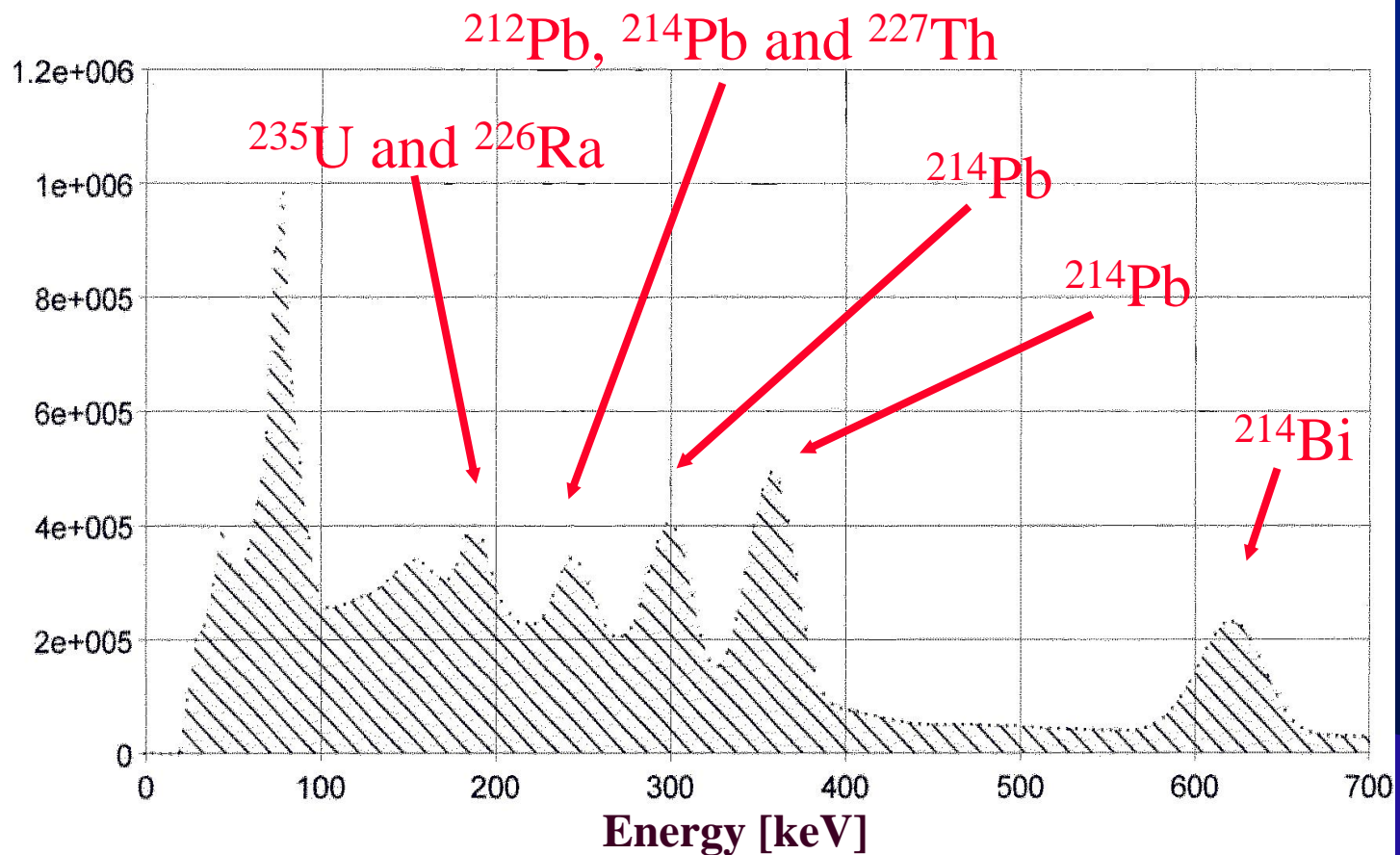
PROBLEM SCALE

- The uranium mill was in operation from 1962 -1991.
- About 16 745 835 tons of U-ore with a low content of uranium (0.184 %) were processed in this period.
- The U-ore was processed by two technologies: about 12 779 200 tons by acid-leached and about 3 989 800 tons by alkaline extraction.
- The sludge beds are distributed on area about 2.3298 km².

WASTE DEPOT



URANIUM MILL TAILINGS



NATURAL ATTENUATION



WHY?

- **Health risk**
- **secondary pollution**
- **food chain contamination**
- **land utilization restriction**
- **socio-economic impact**
- **site-owner duties**

HOW?

- **Laboratory studies**
- **Greenhouse studies**
- **Field studies**
- **Field application**

STARTING CONDITIONS

- **Phytoremediation**
- **metal quantity g/kg of soil**
- **toxic for plants**
- **other contaminants**
- **pH problems**
- **Radiophytoremediation**
- **RN quantity 10^{-6} g/kg of soil**
- **toxic for plants???**
- **other contaminants**
- **pH problems**

PLANT REQUIREMENTS

- **Phytoremediation**
- high accumulation capacity
- relative metal resistant
- high biomass
- “passive” uptake satisfactory
- **Radiophytoremediation**
- high accumulation capacity not necessary
- metal resistant ??
- high biomass ??
- “ACTIVE” uptake necessary !!

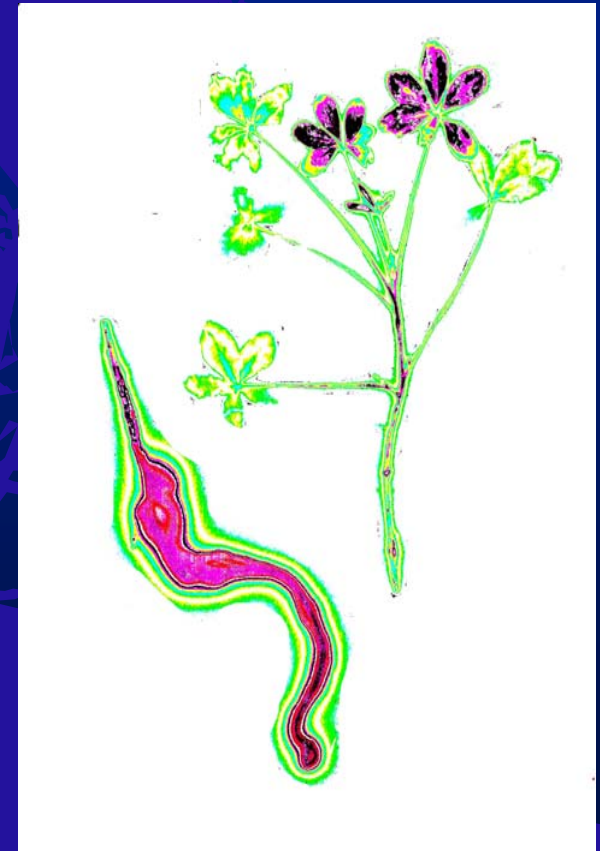
LABORATORY STUDIES

- **Study of uptake of selected metals/radionuclides under hydroponic conditions**
- **Study of accumulation**
- **Study of translocation**
- **Selection of appropriate plant(s).**

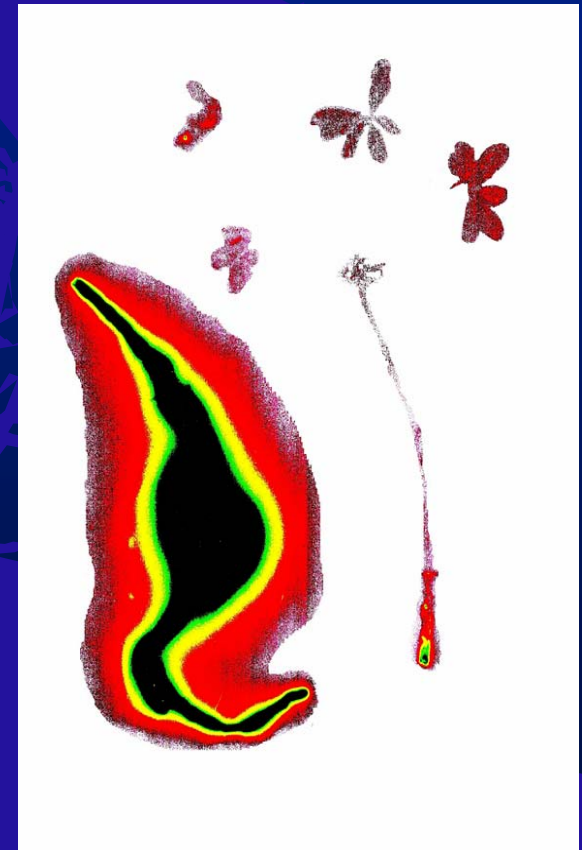
AUTORADIOGRAPHY

- ➡ This method give us possibility to localize areas of metal accumulation in details, which is important for understanding of uptake and translocation mechanism
- ➡ This method give us possibility of selection of most appropriate plants for phytoextraction (most metal accumulated in upper, harvested parts) and phytostabilization (most metal in roots, to prevent food-chain contamination).

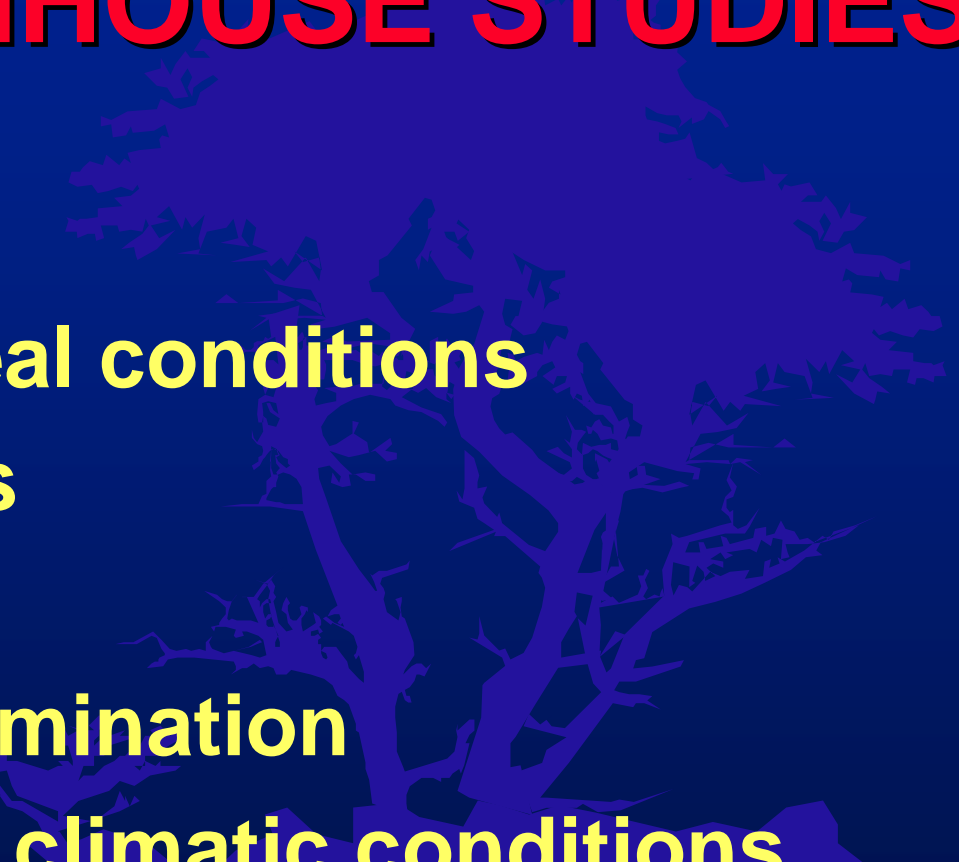
Lupinus albus - ^{109}Cd accumulation



Lupinus albus - ^{210}Pb accumulation



GREENHOUSE STUDIES



- **Close to real conditions**
- **Real plants**
- **Real soil**
- **Real contamination**
- **Controlled climatic conditions**

26 tested plant species and cultivars in year 2004



POT EXPERIMENTS

Substrate composition:

uranium mill tailings + compost 1:2

total activity 10 Bq ^{226}Ra / g of dry weight

Plant species	activity Bq ^{226}Ra/g
<i>Pisum sativum</i>	1,66
<i>Lupinus polyphyllus</i>	0,24
<i>Cannabis sativa</i> "Juso-11"	0,64
<i>Cannabis sativa</i> "Beniko"	0,99
<i>Cannabis sativa</i> "Silesia"	0,47
<i>Zea mays</i>	0,15
<i>Sinapis alba</i>	0,51
<i>Helianthus annuus</i>	0,38
<i>Atriplex halimus</i>	0
<i>Mercurialis annua</i>	0,85
<i>Linum usitatissimum</i> "Jitka"	0,18

FIELD STUDIES

radiophytoremediation and radiophytomonitoring

- **Analyses of RN(s) in soil and water**
- **Planting of selected plant(s)**
- **Study of accumulation and translocation of RN(s)**
- **Soil analyses**
- **Post-Harvest treatment?**

PLANT COLLECTION



Calamagrostis epigeios



Lactarius piperatus

ACTIVITY OF WILD PLANTS

Plant species	activityBq ²²⁶Ra/g
<i>Potentilla reptans</i>	4,09
<i>Mentha arvensis</i>	4,00
<i>Calamagrostis epigeios</i>	3,40
<i>Rubus caesius</i>	2,65
<i>Daucus carota</i>	3,70
<i>Silene vulgaris</i>	2,60
<i>Cirsium arvense</i>	2,46
<i>Hypericum perforatum</i>	2,13
<i>Echinum vulgare</i>	1,79
<i>Sphagnum fallax</i>	1,76
<i>Artemisia vulgaris</i>	0,19
<i>Trifolium repens</i>	0,00
<i>Amanita phalloides</i>	0,00
<i>Sisymbrium loesselli</i>	0,10
<i>Urtica dioica</i>	0,11
<i>Melilotus officinalis</i>	0,06
<i>Tanacetum vulgare</i>	0,08
<i>Melilotus alba</i>	0,02
<i>Polygonum amfibium</i>	0,00

SMALL SCALE FIELD EXPERIMENTS



RESULTS

Plant species	activity Bq ²²⁶Ra/g
<i>Linum utitatissimum</i> "Atalante"	1,22
<i>Euphorbia marginata</i>	1,25
<i>Sinapis alba</i>	2,67
<i>Zea mays</i>	3,58
<i>Mercurialis annua</i>	5,70
<i>Lupinus polyphyllus</i>	3,22
<i>Cannabis sativa</i> "Beniko"	4,30
<i>Cannabis sativa</i> "Juso-11"	3,60
<i>Cannabis sativa</i> "Silesia"	3,52
<i>Pisum sativum</i>	3,72
<i>Amaranthus caudatus</i>	4,70
<i>Sorghum bicolor</i>	4,34
<i>Linum utitatissimum</i> "Jitka"	1,30
<i>Helianthus annuus</i>	1,93

TREATMENT OF PLANT MATERIAL

Activity under legal limit

- ➔ No special treatment necessary
- ➔ Advantage of low accumulation crop plants

Activity above legal limit

- ➔ Waste dump (large volume, transport problems)
- ➔ Incineration (legal problems)

FIELD TEST

7000 m², *Linum usitatissimum*



SAMPLE COLLECTION



FLAX PARTS ACTIVITY

	activity
Contaminated soil	0.06
Seeds	0.00
Fibres	0.00
Awn	0.010
Deseeded capsule	0.05

activity = Bq ²²⁶Ra/g]

CONCLUSION

- Large-scale experiment with cultivation of flax on radionuclide low-contaminated soil proved the possibility of utilization of non-food crops for radiophytoremediation / stabilization purposes.
- The harvested crop can cover at least partially expenses necessary for contaminated area management and make possible to maintain agriculture activity there, which is important from socio-economic point of view.

CONSTRUCTED WETLAND

(in cooperation with Bioplanta)



CONSTRUCTED WETLAND



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